When and Where is the Party? Day and Night Vertical Depth Distribution of Phytoplankton, Zooplankton, and Larval Fish in Lake Michigan during Summer 2010

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INTRODUCTION

When and where planktonic organism encounters occur in lakes is important to understand predator and prey relationships. Phytoplankton concentrations are dependent on light and nutrient availability as well as temperature. Zooplankton species may vary in the water column depending on food encounters and temperature preferences as well as the ability to avoid predation. Within the deep water column of Lake Michigan, physical, chemical, and biological interactions all contribute to the presence or absence of certain planktonic species at various depth zones in the lake. In this study, during the **Year of Lake Michigan 2010**, we set out to observe the current vertical depth distribution of planktonic species during both light and dark time periods. We would like to address the questions (1) who are the most abundant species, and (2) where is the most popular place to be in the water column and at what time? In other words, where's the party?

In addition, Lake Michigan primary, secondary, and fish production have all drastically declined in recent years. This decline appears to be attributed to the expansion of the invasive quagga mussel throughout the lake (Fahnenstiel et al. 2010). This production decline may result in shifts in the dominance of certain planktonic species over others as they adapt to changes in food and an increase in water transparency.

METHODS

The 110-m deep Lake Michigan study site is located offshore of Muskegon, MI, USA. All samples were collected during the day-light period from 13:00 to 17:00 on July 20, 2010 and during the night-dark period from 01:00 to 05:00 on July 21, 2010. A towed fluorometer and CTD (conductivity, temperature, and depth) instruments were used to measure chlorophyll concentration (a surrogate for phytoplankton) and temperature from the surface to the bottom of the lake (Figure 1). A 0.5-meter diameter, 153-micron mesh net with a tripping mechanism was used to collect duplicate zooplankton samples. Zooplankton were collected from different depth zones by triggering the tripping mechanism at various depths. Based on the CTD profiles, the zooplankton were collected in the epilimnion at 12-0 m, the metalimnion at 25-12 m, the upper hypolimnion at 65-25 m, and in the low hypolimnion at 104-65 m. Duplicate larval fish samples were collected with a 1000-micron mesh Tucker trawl at depth zones that represented the epilimnion (9-0 m), the metalimnion (17-9 m), and the hypolimnion (38-17 m) from 5-minute tow intervals.

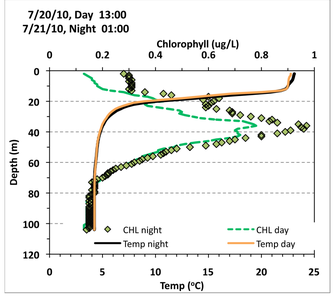

Figure 1. Temperature and chlorophyll profiles reveal water columns that are stratified similarly both day and night. The chlorophyll concentrations reveal a deep chlorophyll layer (DCL) in the upper part of the hypolimnion that peaks at 36 meters during both light and dark periods, however, the chlorophyll concentration for the dark period is higher than the light period at 0.97 and 0.78 µg/L, respectively.

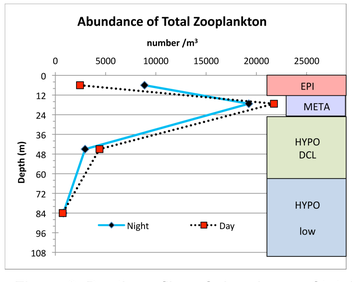

Figure 2. Depth profiles of abundance of total zooplankton reveal vertical movement from the upper hypolimnion and metalimnion during the day to the epilimnion at night, however, the highest abundances remain in the metalimnion. The colored boxes to the right represent the stratified temperature zones of the water column. EPI=epilimnion, META=metalimnion, HYPO=hypolimnion with the DCL=deep chlorophyll layer, and HYPO low=deep zone of the hypolimnion.

RESULTS

Chlorophyll and Temperature

Zooplankton

The most numerous crustacean zooplankton groups present were; Calanoid and Cyclopoid copepods, the Cladoceran, *Daphnia mendotae*, and veliger larvae of Dreissenids (zebra and quagga mussels). The Calanoid copepods were the majority of the zooplankton present, and they represented at least 70% of the total. Of the Calanoids, members of the family Diaptomidae were most abundant and were represented by three main species; *Leptodiaptomus minutus*, *L. ashlandi*, and *L. sicilis*. The large non-diaptomid, Calanoid copepod, *Limnocalanus macrurus* was also present. *Diacyclops thomasi* was the only Cyclopoid copepod present and their abundances were modest.

Larval fish

Five species of larval fish were found at the 110-m-deep offshore site at one or more of the depths zones. The species present were bloater (*Coregonus hoyi*), alewife (*Alosa pseudoharengus*), deepwater sculpin (*Myoxocephalus thompsoni*), burbot (*Lota lota*), and smelt (*Osmerus mordax*). Of the five species, bloater and alewife were the most abundant.

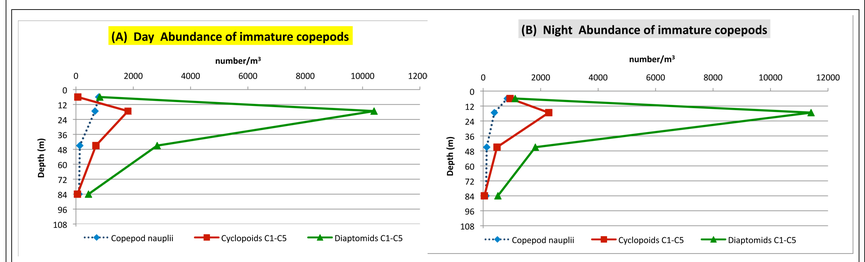

Figure 3. (A, B) Depth profiles of immature copepods (copepodid stages 1-5, and nauplii) reveal the dominance of the Diaptomid copepods over the Cyclopoid copepods. A slight vertical movement upward occurred from day (A) to night (B) for the copepods. Nauplii (post egg stages) were most numerous in the epilimnion and metalimnion during both day and night.

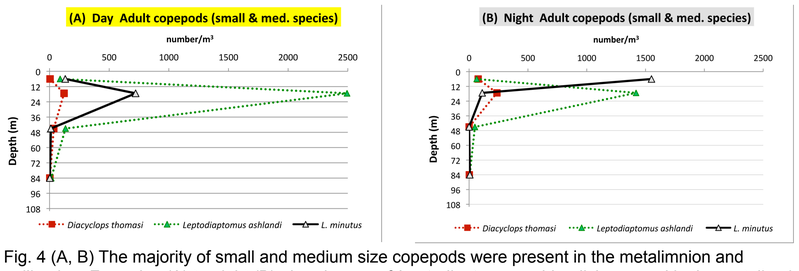

Fig. 4 (A, B) The majority of small and medium size copepods were present in the metalimnion and epilimnion. From day (A) to night (B) abundances of *Leptodiaptomus ashlandi* decreased in the metalimnion, *Diacyclops thomasi slightly increased* in the metalimnion, and *L. minutus* migrated from the metalimnion to the epilimnion.

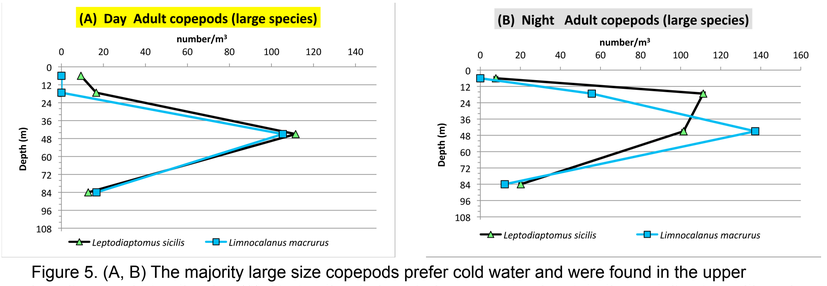

Figure 5. (A, B) The majority large size copepods prefer cold water and were found in the upper hypolimnion during the day (A). During the dark period, many moved up into the metalimnion, although some still remained in the upper hypolimnion.

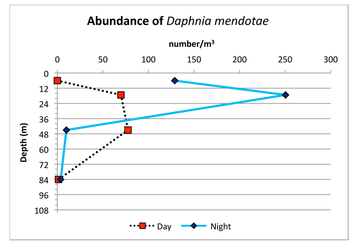

Figure 6. *Daphnia mendotae* is the dominant Cladoceran in offshore waters of Lake Michigan. Compared to some of the copepods, their numbers are relatively low. The depth profiles of *Daphnia* abundance reveal their migration from the upper hypolimnion and metalimnion during the day to the epilimnion and metalimnion at night.

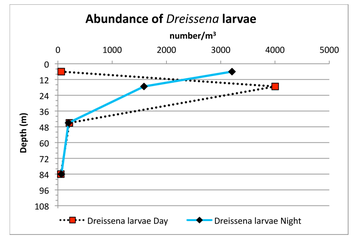

Figure 7. *Dreissena* larvae were the second most abundant plankton following the immature Diaptomids. The depth profiles show migration patterns from the metalimnion to the epilimnion from day to night.

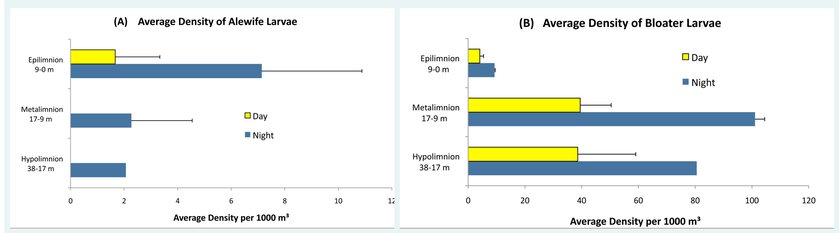

Figure 8. (A, B) Depth profiles for alewife (A) and bloater (B) reveal higher abundances of bloater in all zones. Higher abundances of both larval fish species were found at night than during the day, and bloater (B) were found deeper in the water column than alewife (A).

CONCLUSION

So, where and when was the party? It appears the party was in the metalimnion, and it was the most crowded during the day. The highest percentages of zooplankton were found in the metalimnion during both day and night (Table 1).

	DAY	NIGHT
EPI	7.7	27.2
META	74.4	60.5
HYPO	15.5	9.7
HYPO LOW	2.5	2.5

Table 1. Percent total zooplankton in water column zones.

The metalimnion seems like a good party spot for most zooplankton and larval fish. The temperature was moderate, and the salad bar (chlorophyll concentration) was fairly good. During the night time, more larval fish showed up, and some of the zooplankton crowd dispersed upward into the warm water of the epilimnion, because maybe in the dark, your enemies might not see you leave. For those who prefer cooler temperatures, the upper hypolimnion had a larger salad bar and smaller crowds than the metalimnion. Overall, various Calanoid copepods were the most numerous attendees.